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ENGINEERING-EDUCATION

Bulletin of the
Society for the Promotion of Engineering Education

Vol. IX LANCASTER, PA., OCTOBER, 1918 No. 2

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BULLETIN

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ESSENTIALS IN ENGINEERING EDUCATION.

BY MILO S. KETCHUM,

President, Society for Promotion of Engineering Education.

Engineers and engineering schools have taken a very important part in war activities and have shown the value of technical training. Under the changed conditions due to the war all educational methods and ideals should receive careful scrutiny to see whether or not they fill the needs of the hour. In this brief address the essentials in engineering education will be briefly considered.

Before starting to build a machine or a structure the engineer prepares plans and specifications. If we are to prepare to educate an engineer, we should also have specifications for the finished product. A well-known engineer has given the following definition of a good engineer: "A good engineer must be of inflexible integrity, sober, truthful, accurate, resolute, discreet, of cool and sound judgment, must have command of his temper, must have courage to resist and repel attempts at intimidation, a firmness that is proof against solicitation, flattery or improper bias of any kind, must take an interest in his work, must be energetic, quick to decide, prompt to act, must be fair and impartial as a judge on the bench, must have experience in his work and in dealing with men, which implies some maturity of years, must have business habits and knowledge of accounts. Men who combine these qualities are not to be picked up every day. Still they can be found. But they are greatly in demand, and when found, they are worth their price; rather they are beyond price, and their value can not be estimated by dollars." (Chief Engineer Starling's Report to Mississippi River Commission.) Stated somewhat differently, an engineer must

have general training, must have technical training, must have professional experience, must have high moral character, must have a knowledge of men, must have a broad vision, must have administrative and business experience.

While all will agree as to the specifications and requirements of a good engineer, a careful study of the curricula of engineering schools will show that there is a great difference of opinion as to what are the essentials in engineering education in order that students may be given the proper training so that they may, after obtaining sufficient practical experience, become engineers. A brief discussion of the essentials of engineering education by an engineering educator who has for some months been engaged in engineering administration may be of value.

In the beginning it should be remembered the problem is not only to train the student so that after sufficient experience he may become an engineer, but also to make a man out of a boy. The latter is even more important than the former; and every scheme of education must keep in mind the fact that clean living and straight thinking are the essentials of all educational methods. Students come to college from high schools with very different degrees of preparation, varying from the boy from a well-to-do family who has graduated from an English or classical high school to the boy from a workingman's family who has had just sufficient training in a poor high school to enable him to enter. While schools with private endowments may select applicants for admission by a rigid examination, most state universities find it necessary to admit by credentials and then give the freshman a full term in which to show his ability.

The most critical time in the engineering student's career is during the first semester when he is making the change from a high-school student to a college freshman. The freshman has no appreciation of his new duties and responsibilities and requires very careful direction if he is to make the best use of his opportunities. Freshman teachers should be men

of mature experience, selected for their ability to interest and enthuse students as well as for their teaching ability. If young teachers must be placed in charge of freshmen they should be engineering graduates selected with reference to their ability to interest and enthuse students. In this connection it should be kept in mind that the harshest judge is always one who has been the shortest time on the bench, and also that the teacher who has but recently graduated is usually too critical of the abilities of others and too proud of his recently acquired knowledge to be placed in charge of freshmen classes.

The courses of engineering schools contain little or no engineering subjects during the first two years, and it is difficult to keep up the student's interest. It has been suggested that the student's interest be aroused by the addition during the first two years of properly selected elementary professional subjects. In the University of Colorado the teachers in mathematics, drawing and English are engineering graduates who have had sufficient engineering experience to be able to show the freshmen and sophomores the direct application of their courses to engineering practice. The instructors in mathematics are not only able to teach mathematics, but know from experience the value of mathematics to the engineer. The student immediately feels that mathematics is not something to be gotten by, but is to be a tool that will help him to solve many knotty problems. The instructor in engineering English has had a large experience in technical writing, and is not only able to teach the students to write, but knows from experience the value of English to the engineer. The success of the departments of engineering mathematics and engineering English, with engineers as teachers, is merely an example of the well-recognized fact that the prime essential for a successful teacher is to know his subject. What right, then, have we to expect a teacher of mathematics or of English who has studied mathematics or English merely to teach others to

teach, to successfully teach engineering students who are interested in doing things?

An engineer requires training in pure science so that he may be able to apply scientific laws and principles to the solution of engineering problems, and also in order that he may make researches for himself. It is more important that he be given basic courses in science that will open up the field and that will teach him to use scientific methods in taking up a new line of work, than that he be given extended courses going into the technique of the subject and including a large number of experiments.

Mathematics should be taught concretely and not abstractly. The principal difficulty with students and engineers is to express observed facts and data in mathematical terms preliminary to the mathematical solution of the problem. The student should be taught that mathematics is merely a mill into which data are fed to be turned into a form that will be useful to the engineer. He should also be taught that mathematics and mechanics will never take the place of judgment, but are useful in making experience already gained applicable to new conditions, and also that no mathematical process can give results that are any more accurate than are the data upon which the calculations are based. The student should be given training in graphic calculation in order that he may be able to visualize the problem, and thus prepare the data for the mathematical process. Many problems that are very difficult when solved by algebraic processes are very simple if solved by graphics. Teachers of mathematics in high schools and liberal arts colleges, as a rule, have had no training in graphics, and therefore do not use graphics in mathematical instruction. Many students who have shown very little ability to understand algebraic processes are able to understand the same problems when solved by graphics. The engineer should be able to use algebraic or graphic methods with equal facility. By properly choosing the method, it is possible to save a large amount of time in calculations, or one

method may be used in making the original calculations and the second method may be used for check solutions.

Many problems in mechanics that are very difficult to solve by algebraic methods are very easily solved by graphics. The calculation of stresses in a continuous beam of variable cross-section, which is a very difficult problem when solved by algebraic methods, is a very simple problem when solved by graphics. The details of this solution are so simple that they may be understood by a freshman of average ability. Graphic methods are capable of as great accuracy as are algebraic methods, and at the same time, are less liable to large accidental errors or mistakes.

All measurements and data used by the engineer in his calculations are approximate values and the results of calculations are therefore at the best only probable values. There is therefore no subject of mathematics that is of more value to the engineer than that of the theory of probability. The theory of probability has been defined as that line of mathematical reasoning by which one is able to determine by scientific methods a result that would be arrived at by one who has had a very large experience and trained judgment. Many of the laws of mechanics may be derived by applying the laws of the theory of probability, which fact shows the direct connection between mechanics and the theory of probability.

Drawing and surveying should be taught to develop the student rather than to make draftsmen or surveyors. In teaching surveying, better results are obtained by the men working in squads than in large parties, as is the custom in actual pracice. The assigned problems should be designed with the idea of developing the theory of surveying instruments and their application rather than with the end in view of making a surveyor.

In the beginning of engineering schools, the curriculum consisted mainly of languages, mathematics, chemistry, and physics, together with surveying and brief courses in engineering construction. Engineering teachers were for the

most part men with little or no engineering experience, and as a result the training in the engineering school did not prove to be of any material benefit aside from the libert arts training. The engineering graduate was not looked on with favor, either by the financial man who employed him, or the practical engineer under whom he worked. There was a constant conflict between engineering theory and engineering practice.

With the advance in pure and applied science, the curriculum of the engineering school has changed from an inferior liberal arts course with a smattering of engineering practice, to a course in applied science with a close and intimate contact with the latest advances in engineering practice. Engineering schools now have fully equipped laboratories in which commercial tests are made of materials and machines. Many engineering teachers have made notable additions to scientific knowledge as applied to engineering construction. The feeling of antagonism between practical engineering and theoretical engineering has disappeared, and engineers and technical schools are now working in very close coöperation. Engineering contractors find that they must needs keep in touch with the laboratory if they are to solve present-day construction problems. The most approved and latest advances in mechanics together with properties of materials are now recognized as essential to engineering construction. There is no longer any conflict between engineering theory and engineering practice. It is now universally recognized that a satisfactory design can only be evolved after all of the theoretical and practical considerations have been taken into account. The engineer is no longer satisfied with rule-of-thumb methods, which were the basis of the art of engineering. The engineering teacher is no longer looked upon as an interesting specimen that must be tolerated and endured, but is now given an honorable position in the engineering profession.

An engineer is a man who not only designs and builds safely, but who designs and constructs a structure or machine

that is adapted to the needs, with a cost commensurate with the service rendered. The design of a structure requires not only the knowledge of the properties of materials and the ability to calculate the stresses, but also a knowledge of local conditions and requirements, of economical design, of details of construction, of methods of erection, methods of fabrication, and their effect on cost, and many other matters which limit the design. The most economical structure for any given conditions is the one which will give the greatest service for the least money, quality of service and life of the structure being given the proper consideration. Financial limitations often limit the design and the problem then is to design a structure that will give satisfactory service with the money available.

To design a satisfactory structure when limited by financial considerations is a problem that requires the exercise of the highest possible skill on the part of the engineer. He must be able to select an economical type of structure; he must make an accurate estimate of the loads to be carried by the structure; he must be able to calculate the stresses with accuracy; he must make the details of the design with due reference to ease of obtaining the material, to cost of shop work, and cost of erection.

The successful engineering contractor must be trained not only in applied science but in business methods and in addition have some familiarity with the law. He must not only be able to build well, but must have the initiative to work out any problems in a way that will bring satisfactory results to both his client and to himself.

The successful engineer must not only have a thorough engineering training, but he must be trained to know men. The engineer must not only know how to design or to build, but must be able to impress others with his ability. In administrative positions, the ability to select subordinates is a prime essential. More engineers fail in administrative positions due to their inability to select men than due to any other one

thing. As a class, engineers are prone to judge men too much on their technical ability alone, and give too little attention to those qualifications and characteristics in men that make it possible to use technical knowledge. A man with a disagreeable disposition ordinarily has no opportunity to use his technical ability except in a very inferior position. One of the most important advantages gained from technical education is contact with other men and an appreciation of the value of human engineering. Of all the materials with which an engineer has to deal there is no material so difficult to handle and control as human material.

In addition to the usual courses in mathematics, mechanics, science and languages, the engineering course should include training, either formally or informally, in ethics and in a man's relations to his fellows. A well-balanced engineering course must not only give training in technical and humanizing subjects, but must give training in straight, logical thinking. The engineering student must be impressed with the idea that in the end he must appeal to the good sense and intellect of his hearer if he is to be able to put his plans into execution.

Methods of teaching students in the class-room and the laboratory are directly applicable to engineering construction. The inspector on concrete construction should instruct the foremen and workmen so that they will understand the effect of a poorly graded aggregate, the effect of too much water, and other details that determine the quality of concrete, rather than undertake to control the work by the force of his authority. The improved methods of construction proposed by the engineer must stand the criticism of the superintendent or the foremen if they are to be effective. A large engineering project is in effect a large engineering school in which the engineer and his assistants are the faculty, the superintendents and foremen are their assistants, and the workmen are the students. The more effective the work of the teacher and his assistants, the better will be the results. Where the

workmen as well as the foremen are kept interested in the work, the results are sure to be satisfactory. Interested workmen means efficient workmen. On large construction projects the organization is necessarily so complicated that the workman is easily lost sight of. If workmen are to be efficient, they must be well housed and well fed, and be given adequate opportunities for recreation. The workmen must have sanitary quarters and be given adequate medical attention. The success of engineering construction depends so much upon the character and quality of the service rendered by the workmen, that the engineer in responsible charge should have had considerable training and experience along the line of welfare work and sanitation.

With small construction jobs, it was possible for the superintendent with a limited personnel to accomplish satisfactory results without organization through his own personality. With large engineering projects, where the work must be completed in a very short time, the problem is a very difficult one. The main error in the organization of very large projects is that the administrative machinery is gathered together very rapidly without proper coördination. The problem of harmonizing the different elements in an organization of this character and working it into a single unit is one that appeals especially to an engineering administrator. The problem is one of education and not one in which the results can be obtained by exerting authority. The administrator should have absolute authority in order that he may not find it necessary to use the authority.

The results accomplished in military training camps show that educational methods have been very wasteful and inefficient. The idea that the student's initiative can be developed by turning him loose in the laboratory, the drawing room or the field to work out the problem without instructions is no longer tenable. No man has a right to have initiative until he has knowledge. If the student is taught to think straight

and that all work must be planned in advance, he will in due time develop initiative.

The efficiency of engineering education can be greatly increased by the use of proper pedagogical methods. The subject-matter of each course should be selected with the idea of developing the subject in a logical manner. The course should be developed with full notes and definite instructions for all experiments or problems. The most direct method in learning is to study a similar problem that is fully worked out, or to follow a problem survey that is fully worked out with notes or calculations. The use of sample problems, field notes or laboratory experiments, not only assists the student in learning the particular matter in hand, but gives him training in keeping his notes in an orderly manner and shows him that the best results from subordinates can only be obtained when they are given very carefully prepared and definite instructions.

The problems assigned to students should not be too complex or too complicated, but each problem should be selected to bring out and illustrate a few or even one important principle. Better results in teaching topographic surveying can be obtained by giving the student a series of field problems illustrating the different divisions of a survey, than to have the student assist in a large topographic survey where he has only a limited responsibility. All problems or exercises should as far as possible require that the entire solution be carried through by each student independently. The old saying that "a boy is a boy, two boys is a half a boy, and three boys is nó boy at all" is almost literally true when applied to students.

In all calculations, experiments and field work great care should be used to impress the student with the great importance of the use of consistent accuracy. The student should be shown that all data which the engineer uses are approximate, and that the results of his calculations are therefore only probable values. He should be shown where he may use

a slide rule, where he should use five-place logarithms, and where seven-place logarithms. It will also be useful to show that six-place logarithms require more work in their use than do five-place logarithms with no gain in accuracy. The student should also be taught to use the different calculating machines. While the slide rule is a very useful tool its constant use by the student is open to question, for the reason that he does not get adequate training in performing ordinary arithmetical calculations. The engineer should be able to run hurriedly over calculations performing all arithmetical operations by short cuts or approximate methods, in order that he may be certain that the result is consistent. A common error with students and young engineers is to point off incorrectly, or to work out the details of one column of a tower and then forget to multiply by four.

In teaching engineering design it is very important that the student be given careful instructions. The size of the sheet and the scale of the drawing should be selected so that satisfactory results may be obtained. The time occupied in preparing a drawing of a particular machine or structure varies almost directly as the area of the drawing. Careful tests have shown that in teaching structural design a size of plate of 18 inches by 24 inches is much more economical of the student's time than a plate 24 inches by 36 inches. It should also be noted that the scale of the drawing on the smaller plate is seven tenths of the scale of the drawing on the larger plate. There is an additional saving of time in finishing drawings in pencil. By the use of drawing plates 18 inches by 24 inches in place of plates 24 inches by 36 inches, and by finishing drawings in pencil, the work in structural design in a given course may easily be doubled. While the recent graduate should have some familiarity with tracing, it is very much more important that he be able to make a good pencil drawing.

The student should be given an opportunity to get a familiarity with good literature so that he may in time become a well-read man. This may be done by regular courses or

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by means of supplementary reading courses. The idea that certain courses were humanistic and therefore liberal, and that other courses were materialistic and therefore not giving a liberal training is no longer tenable. The humanizing and liberalizing value of any subject is in the teacher and is not in the subject. The most important part of any institution of learning is the teacher. The engineering teacher should be a man that will fill the specifications prepared by Engineer Starling in his report to the Mississippi River Commission, and in addition he should have teaching experience and a love for his work. While teachers of this type are worth the price, it is at present very difficult to obtain sufficient funds to keep able teachers from going into practice.

The most critical problem in engineering education to-day is to obtain a sufficient number of competent teachers. The Society can undertake no greater task than to improve the conditions and increase the emoluments of engineering teachers so that engineering students may all have instruction under men of thorough training in theory and practice who can comply with the specifications for a good engineer.

STUDENT ARMY TRAINING CORPS.

WAR DEPARTMENT.

COMMITTEE ON EDUCATION AND SPECIAL TRAINING.

Special Bulletin on Programs in Engineering.

The programs here presented are not prescribed, but are examples of what will be approved. They are intended to indicate how existing programs may be modified by eliminations and condensations so as to meet the needs of the present emergency. Each program covers eight terms of twelve weeks, but it must not be inferred that every student entering on such a course will be kept at college until he completes it. The time that he will be permitted to pursue the course will depend on the needs of the service and the academic record of the student. In addition to the instruction indicated in these courses, eleven hours per week of military instruction are prescribed for the first two terms of the program, and six hours per week for the remainder of the program. The total time to be devoted to military and academic instruction, including examinations, lectures, recitations, laboratory work and supervised study, is 53 hours per week. The hours set forth in the programs attached represent the total time devoted each week to the subject named. The relation of the time given to study to that assigned to lectures, recitations and laboratory work varies considerably with the nature of the subject, but on the average the former is not more than half of the total time allotted. The subject, War Issues, which must be combined with English Composition, is, with the exceptions indicated in Section 26 of the Regulations of the S. A. T. C., prescribed for two terms with nine hours per week for lectures, recitations and study.

It is suggested that as far as practicable students in the Naval Section of the Students Army Training Corps follow

an approved course in Mechanical Engineering. Steam and gas engine subjects are necessary for students who attempt to qualify for the Navy engineering schools.

CIVIL ENGINEERING.

First Term.

	Hours per Week.
Mathematics	12
Chemistry	12
*Drawing and descriptive geometry or surveying	9
War issues and English composition	9

Second Term.

	Hours per Week.
Mathematics	12
Chemistry	12
*Drawing and descriptive geometry or surveying	9
War issues and English composition	9

Third Term.

Mathematics	12
Physics	14
Mechanism and applied mechanics	15
*Drawing and descriptive geometry or surveying	6

Sixth Term.

Theory of structures	9
Bridge design	4
Railroad engineering (including drafting)	9
Hydraulics	13
Electrical engineering	12

Fourth Term.

Mathematics	9
Physics	14
Mechanics	15
*Surveying or drawing	9

Seventh Term.

Theory of structures	12
Bridge design	10
Railroad engineering	4
Heat engineering	12
Hydraulic and sanitary engineering	9

Fifth Term.

Theory of structures	6
Materials	10
Railroad engineering (including drafting and fieldwork)	15
Highway engineering	6
Map reading and topographical drawing	2
Geology	8

Eighth Term.

Theory of structures	12
Hydraulic and sanitary engineering and design	16
Heat engineering	9
Railroad design	3
Sanitary science and public health	1
Business law and accounting	6

* These courses will be divided between surveying and drawing in accordance with the season of year in which they come and the number of students registered. The total time allotment to surveying is equivalent to twelve hours per week for one term.

STUDENT ARMY TRAINING CORPS.

MECHANICAL ENGINEERING.

First Term.

	Hours per Week.
Mathematics	12
Drawing and descriptive geometry	9
Chemistry	12
War issues and English composition	9

Second Term.

Mechanism	9
Mathematics	12
Chemistry	12
War issues and English composition	9

Third Term.

Mechanism and mechanical engineering drawing	10
Mathematics	12
Physics	14
Shopwork	4
Surveying, map reading, and topographical drawing	7

Fourth Term.

	Hours per Week.
Applied mechanics	12
Mathematics	12
Mechanical engineering drawing	5
Physics	14
Shopwork	4

Fifth Term.

Heat engineering and English laboratory	15
Electrical engineering	10
Applied mechanics	12
Machine drawing	6
Shopwork	4

Sixth Term.

Heat engineering and English laboratory	15
Hydraulics	11
Applied mechanics	10
Electrical engineering laboratory	7
Shopwork	4

Seventh Term.

Materials of engineering and testing materials laboratory	12
Mechanism of machines	5
Machine design	10
Applied mechanics	10
Refrigeration	2
Engineering laboratory	4
Shopwork	4

Eighth Term.

Power plant design	8
Industrial plants (including heating and ventilation)	16
Mechanics of engineering	7
Engineering laboratory	10
Gas motors or heat treatment	5
Shopwork	4

* These courses will be divided between surveying and drawing in accordance with the season of year in which they come and the number of students registered. The total time allotment to surveying is equivalent to twelve hours per week for one term.

STUDENT ARMY TRAINING CORPS.

ELECTRICAL ENGINEERING.

First Term.

	Hours per Week.
Mathematics	12
Drawing and descriptive geometry	9
Chemistry	12
War issues and English composition	9

Second Term.

Mathematics	12
Chemistry	12
Drawing and descriptive geometry	9
War issues and English composition	9

Third Term.

Mathematics	12
Physics	14
Mechanism and applied mechanics	12
Mechanical engineering drawing	9

Fourth Term.

Mathematics	12
Physics	14
Elements of electrical engineering	2
Applied mechanics	12
Surveying, map reading, and topographical drawing	7

Fifth Term.

	Hours per Week.
Elements of electrical engineering and direct current machinery	15
Electrical engineering laboratory	8
Heat engineering	9
Materials of engineering	6
Shopwork	9

Sixth Term.

Variable and alternating currents	12
Electrical engineering laboratory	12
Heat engineering	9
Mechanical engineering laboratory	8
Structures of machine design	6

Seventh Term.

Alternating current machinery	9
Electrical engineering laboratory	8
Hydraulics	9
Electrical transmission (power and telephone)	15

Eighth Term.

Alternating current machinery	19
Electrical engineering laboratory	6
Power stations (steam and hydro-electric)	13
Motor applications, lighting and storage batteries	15
Business law and accounting	4

COMMITTEE ON EDUCATION AND SPECIAL TRAINING,
By R. C. MACLAURIN,
Educational Director, Collegiate Section.

September 19, 1918.

THE COMMONWEALTH EDISON COMPANY'S PLAN FOR RECRUITING ENGINEERS.

BY W. L. ABBOTT,
Chief Operating Engineer.

The Commonwealth Edison Company, like all other large employing companies, is beginning to be greatly concerned regarding several things which are the outgrowth of the war. Among other things are the scarcity of labor and the scarcity of engineers.

We have, for a number of years, been resorting to artificial means to maintain a sufficient quota of young engineers for our company. In the good old days, the young man from an engineering college would be hired for two dollars a day and put to work in the gang. If he stayed for any length of time, it was not because of any attention we had given him. For a time engineering graduates gladly came to us on these terms, but later on, we noticed they did not come so eagerly as they formerly did, and those we got would stay only so long as they were being given interesting work in which they were learning something. This scarcity of engineers, or their reluctance to come to us, was a progressive feature, noticeable at first with men from eastern universities and technical schools and gradually extending to the men from the universities of the central West. After graduates from these two localities began to find better employment elsewhere, we still got a supply from universities in the South and from those west of the Mississippi River. These men we trained for positions as switchboard operators in power houses and sub-stations, which positions they were glad to take, when other technical men would not consider them, but finally, when men from these last-mentioned sources were getting scarce, and we realized we were no longer getting the best material, our

company in connection with some other public-service companies started an educational department, which we called "The Central Station Institute." This institute was a combination of a post-graduate course with a system of practical training in the various departments of the companies. Originally it was intended to secure and train young men for positions as sales engineers and business solicitors. In an eleven-months course, they were given a few weeks experience in each of several departments of the company and finally were located in the contract department to learn the details of the work required of them there and developed into salesmen. Later this program was enlarged so as to include the training of men for the engineering and operating departments. Half of each day was spent in the classroom and the other half working in the department to which the student was assigned. They were charged a tuition fee of $100 for the course, but were allowed $40 a month for the work they did.

This course was quite popular and successful for a time. About eighty-five students graduated in it during the four years which it ran, and up to a year and a half ago about half of them still remained with the supporting companies. They were for the most part superior men and promising material for positions as department heads, but with the outbreak of the war, nearly all of them packed up their old kit bags and went away into the army and navy, practically terminating the experiment.

After the entry of this country into the war, it was found, not only advisable, but necessary, to materially change the course. The work was divided into five periods of three months each, the first two periods of which could be done during vacation time between school years. Instead of five half days each week being spent in the classroom, the new course provided for but one half-day classroom work a week, and instead of being paid $40 a month, the new rates range from $60 to $90 a month. As before the men are shifted around from one department to another, staying not long enough in

any department to become of much benefit there and not long enough to carry away very clear ideas of the details of the work of the department. It is believed, however, that after a student has been around in this way for a year or more, he will have a comprehensive general idea of how business is transacted in large corporations, how the different departments coördinate their work, and the relative magnitude and importance of each. This in general is the method which we are using to attract and to interest technical students. In normal times, with a less desirable course, we had to place a limit to the number we would admit to the course, but at the present time, we have less than twenty such students. Under the old course we paid them half as much and got twice as many.

I believe a sufficient time has elapsed so that I can now confess my lamentable ignorance of most things practical relative to mechanical engineering at the time of my graduation, and I have a keen realization of what a great benefit it would have been to me, if at the end of my sophomore year I had secured a job in a power house and had been put through boilers, turbines, auxiliaries and switchboard equipment, had such things been in existence in those days. I would have had a much clearer idea of the things that I wanted to study about.

This plan is working so well that it suggests the advisability of not waiting until the end of the sophomore year before starting this practical training. The cadet might be taken in at the end of his freshman year or even during his high school. A young man who has spent three months of the year for four to six years in the various departments of a large company will come near knowing what the company is made of and he would, after graduation, be already equipped for a very satisfactory position.

I mentioned that eighty per cent. of the graduates of this course left us at the beginning of the war to go into the army or other military occupations. All together, one thousand

men have gone from our company and many of them are engineers. We view with alarm, to use that expression, the situation which will exist at the end of another year or two of war should this condition keep up. Not only have our old men gone, but we are not getting new ones. The very men that we want the government is combing the technical schools to get.

We believe that a serious mistake is being made in allowing our engineering students to quit their work and go into the army, particularly where they are going into what you might call non-technical positions. This is true not only of the upper classes, but of the lower classes as well. If the young men who left their classrooms a year and a half ago had then been compelled to go back to school and finish the year and come back this year and finish this year's work, the country would have had hundreds or thousands more engineers available now than it has. We cannot predict the duration of the war, but the longer it runs the more serious the situation will become, and unless some steps are taken to take care of this deficiency, we will have a very serious situation.

Various schemes have been proposed for maintaining the supply of engineering students, and out of it all I sincerely hope that something will come. You doubtless are familiar with the experience of Great Britain at the outbreak of the war in regard to their medical students who quit their medical courses and volunteered as soldiers in the first rush. Naturally, many of them were killed, and after a few months the authorities realized what a serious mistake had been made. They took the remaining students out of the army and sent them back to their schools. It may be that some such action on the part of this government in reference to the engineering students would be advisable at this time.

EFFECT OF THE WAR ON ENGINEERING GRADUATES AND THE INDUSTRIES.

BY G. F. PFEIF,

General Electric Co.

The war has emphasized the extent that our present civilization and its maintenance are dependent on the engineering graduate. We have all accepted modern conveniences without much thought of the engineering skill involved in their production, but modern warfare, with its airplanes, submarines, heavy artillery and other destructive agencies, has shown clearly the need and value of technical training.

When it became evident that our country would take an active part in the war, the first call came for suitable men for training as officers. It was soon demonstrated that men with technical training could readily grasp the fundamentals and principles necessary for the development of a civilian army. Similar conditions existed in the Navy, to a lesser extent, and the expansion of this branch of the service required trained men for the operation of modern equipment on battleships, destroyers and submarines.

Engineering graduates left the industries by the hundreds to take up such work. Others have taken positions in other branches of the service; such as Ordnance, Inspection, Aviation and Signal Corps and to-day the demand is greater than the supply. Almost all of the class of nineteen-seventeen in the engineering colleges have been absorbed and the various engineering organizations have been depleted to such an extent that their efficiency is threatened. It seems that the supply of technical men in the country has been drained during the first year of the war and no adequate provisions have been made for the future. Should the war be of short duration this would not be a matter of prime importance but, on

the other hand, if the war is to continue for a considerable number of years, the situation must receive intelligent and far-sighted consideration.

Our engineering industries are confronted with the big problem of furnishing equipment and munitions, and this has resulted in the building of new munition plants of all kinds, ship-yards, power houses, textile mills, etc., all requiring engineering skill for rapid construction and efficient operation. Hundreds of ships are under construction requiring engineers for the design, supervision of construction, installation of equipment and operation. The manufacture of war materials has added many problems to the work of established organizations. The production of munitions, the reduction of importations and increased demand have created a scarcity of various materials. The engineer has had to produce substitutes which would be equivalent or devise new methods of construction. Speed is essential and in the electrical field the application of the steam turbine and electric motors to ship propulsion, the development of the wireless telephone, the production of searchlights, signal corps apparatus and submarine equipment and detectors have added to the duties of the engineer. Many of the parts are given their first trial under operating conditions, adding to the responsibility and increasing the necessity for accurate work.

Prior to our entrance in the war, it was said that the enemy was superior in engineering skill but subsequent events have shown that it was superior organization. We should, therefore, establish closer coöperation among our engineers. In many cases, men in professional life have offered their services, either partially or entirely, but we have a great amount of engineering talent, especially in the technical colleges, which has not been utilized. These men are anxious to help and can render useful services if called upon by the government or by the industries in a consulting capacity or for the solution of special problems.

It is easy to train men for various shop operations involv-

ing the use of a single machine tool and the production of standard parts but it has been demonstrated that men cannot be trained for technical work in a shorter time than it takes in the technical colleges. The loss of many men has made it necessary to increase the executive work of the engineers remaining in the industries and girls, or men outside of the draft, have been supplied for calculating and elementary work. However, the engineering college must be given more recognition if we are to have enough engineers to win the war and hold our place in the industrial world in the future.

To this effect, the following suggestions are offered as a possible basis of improvement:

1. Professors and instructors, teaching engineering subjects, should be given deferred classification on the same basis as other occupations.

2. All students whose work is satisfactory should be allowed to remain in college until graduation.

3. All graduates should be assigned to engineering work, either in the service or in the industries.

4. Promising high-school boys should be encouraged to enter college and, if necessary, a part of their tuition should be paid. These boys could be selected from scholastic records or by competitive examination. This should receive special attention in view of proposed changes in the draft.

5. Engineering graduates, enlisted or drafted as privates, should be transferred to technical work. The present system of classification does not seem to be entirely adequate in this respect, as a number of recent graduates are in service which does not utilize their training. Such cases should be called to the attention of the various sections of the War Department which are in need of technical men.

6. Recognition should be given engineers of draft age who remain in industrial work. These men are rendering valuable service but are often judged as slackers by people who cannot recognize service without a uniform.

The engineer has not taken the part in political life to which

he is entitled and, until recently, has not had sufficient representation in the councils which have formulated present policies. As a result, there is a feeling that there is no scarcity of engineering material and no danger of a shortage after the war. In the industrial world, the shortage is acute at the present time and the continued expansion of the army and navy will increase the difficulty of obtaining technical men. Every effort should, therefore, be made to maintain a normal number of students. They will be needed, not only for military work and the production of war material but for the production of the ordinary necessities of business after the war. The cost of labor has increased to such an extent that the highest grade of engineering skill and manufacturing efficiency will be needed if we are to compete with the cheaper labor of Europe and the Far East.

Any concerted action by the various engineering societies which would tend to improve existing conditions will meet with the coöperation of the industries.

EDITORIAL.

The Reconstruction Period in Education.—The problem of education, like other problems which have been raised by the entrance of the United States into the war, have been, or are in process of being solved through the various governmental agencies which have been created for this purpose.

The President and Congress are now at work on the various problems of reconstruction which will follow the war. These problems in so far as they deal with education are the types of problems with which this Society should deal. It was recently said to the writer by an Army officer that the war had resolved itself into a question of efficient teaching. If this is true in war times it is certainly true in times of peace, and we may look to see education, especially that which deals with engineering, much modified and enlarged as a result of the war.

Such problems as expansion of industrial research; its relation to colleges of engineering; the development of men for research both in and outside of the institutions; the relation of the teaching staff to industrial development both as regards position of teachers who do consulting work and teachers who do research work; the more thorough organization of teaching with the resulting increase in efficiency which will be brought about through the present organization; all these questions must be dealt with and the answer secured at least in part at the earliest possible time. For instance, it has been the policy of this country in general to say that good teachers must be good investigators. Many disagree with that although we know that the research work adds much to the enthusiasm of the teacher. On the other hand, have we given sufficient attention to the proper organization of teaching to be able to speak with any degree of authority in regard to this matter? The forthcoming meeting of this Society at Boston on December 6–7 will give us an opportunity to hear representatives of Great Britain who have solved some of these questions.

SPECIAL MEETING OF THE SOCIETY TO DISCUSS TECHNICAL EDUCATION WITH THE BRITISH MISSION.

The following letter was received by the Secretary from Dean Henry V. Ames, chairman of the Committee of the American Educational Council:

"At a meeting of the special Committee of the American Council on Education on the Reception of the British Educational Mission to the United States which was held yesterday, the desirability of a meeting of the Society for the Promotion of Engineering Education, to be held probably at the Massachusetts Institute of Technology on December 6 and 7, to discuss with the members of the British Mission technical education in the United States, was considered. The committee felt that in case the proposal for holding a meeting, probably at Harvard University on December 4 and 5, of the Association of American Universities and possibly also of the National Association of State Universities to meet with the British Mission, which is now likely to be arranged—it would be desirable to hold in conjunction therewith a further conference with representatives of technical schools to discuss such topics as: (1) The Liberal Element in Technical Education, (2) The Effect of the War on Technical Education in Great Britain and America, (3) The Organization of Technical Education in the United States. President MacLaurin has offered in behalf of the Massachusetts Institute of Technology to act as host in case such a meeting can be arranged to be held there.

"It is not yet definitely determined that the National Association of State Universities will be able to change the date and place of their meeting to unite with the Association of American Universities. Neither is it definitely determined that Harvard University will be the place for the joint meeting, should there be a joint meeting. It is, however, probable

that Harvard will be the place and December 4 and 5 the dates of the meeting for the discussion of topics relating to higher education of a non-technical character.

"In behalf of the Committee on the Reception of the British Educational Mission, I am writing to inquire whether the suggested arrangement would seem to you to be feasible and whether your Society is prepared to coöperate."

The council voted 38 in favor of holding the meeting and 2 opposed. The following suggestions were contained on the cards received from council:

"Would suggest meeting of council instead of general meeting or one representative from each college."

"If the British Mission is not large would suggest in place of below proposed, a meeting of the council with the mission and the expense of a full meeting and the time required from our War Councils would be too great unless it could be in the interval between quarters, December 21 to 30 and in the middle of the country."

PRELIMINARY PROGRAM OF SPECIAL MEETING OF THE BRITISH EDUCATIONAL MISSION TO THE UNITED STATES AND THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS., DECEMBER 6–7.

Friday, December 6. Opening session 2 P. M., President John F. Hayford, presiding.

Address of Welcome on Behalf of the Massachusetts Institute of Technology. R. C. MacLaurin, President, Massachusetts Institute of Technology.

Address of Welcome on Behalf of the Society for the Promotion of Engineering Education. John F. Hayford,

President, Society for the Promotion of Engineering Education.

Response to Addresses of Welcome. British Educational Mission to the United States.

The Organization of Engineering Education in Great Britain. British Educational Mission to the United States.

The Organization of Engineering Education in the United States. Charles S. Howe, President, Case School of Applied Science, Cleveland, O.

Discussion.

Saturday, December 7, 10:00 A. M., Morning session, President Hayford, presiding.

The Effect of the War in Engineering Education in Great Britain. British Educational Mission to the United States.

The Effect of the War on Engineering Education in the United States. M. E. Cooley, Dean, School of Engineering, University of Michigan.

Discussion.

12:30 P. M. Luncheon.

2:00 P. M. Afternoon session, President Hayford, presiding.

The Liberal Element in Engineering Education. British Educational Mission to the United States.

The Liberal Element in Engineering Education. George F. Swain, Professor, Civil Engineering, Harvard University.

Discussion.

Adjournment.

NOTE.—*Owing to the inability of Prof. M. E. Cooley to attend, the subject "The Effect of the War on Engineering Education in the United States" will be handled by Dr. C. R. Mann, Massachusetts Institute of Technology, Cambridge, Mass.*

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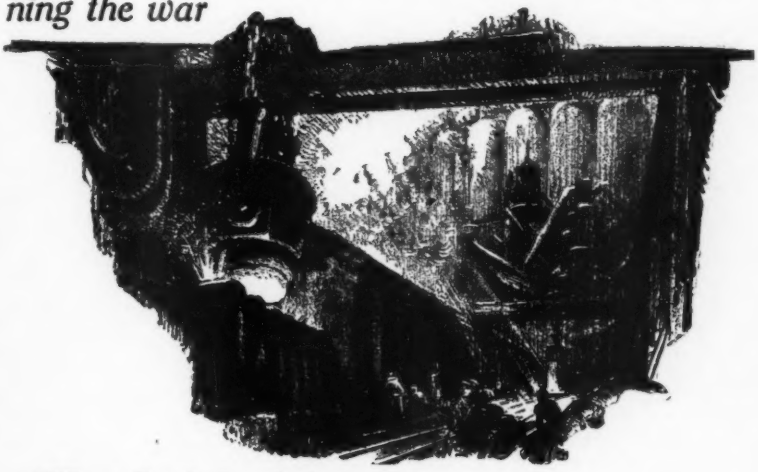

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